Color Management Module for Metal Can Packaging

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Abstract

This project involves color management on metal cans packaging case study of Asian Pacific Can Co., Ltd. The objective is to study color management in metal printing by both indirect offset printing on film and direct offset printing on paper. A test form is designed and printed using an offset printer and coated with varnish controlling density to meet in-house standards. and measurements are taken for density, dot gain, color difference values, and image analysis. and create ICC profiles through Oris Flex Pack software, print onto film and paper using an inkjet printer. The quality of printing on metal sheets, film, and paper is compared. Experimental results show that printing on paper provides print quality similar to actual printing. While prints on film yield slightly different results. When comparing color difference values ΔE_{00}^* between paper prints with real printing, the color difference value $\Delta E_{00}^* = 0.99$ comparing the printing on film with real printing, the color difference value $\Delta E_{00}^* = 1.13$ when comparing paper prints to film prints, the color difference value is $\Delta E_{00}^* = 1.47$ The color difference values for both film and paper prints are within standard criteria, indicating that paper can achieve printing results similar to actual prints.

Keywords
color management, direct offset printing, indirect offset printing, color difference values

1. Introduction
Color measurement in printing is a method used for print quality control. It employs the principle of converting light reflection from objects in the wavelength range of 380-760 nanometers into XYZ tristimulus values through human eye sensitivity functions and spectral values of light sources. These XYZ tristimulus values are then converted into various color systems that correspond to human vision, such as Lab*, XYZ, and LCh* [7]. Color measurement from different inkjet printing systems on different printing materials results in varying color production capabilities. Therefore, knowing a printer's color production capability reveals the specific color production characteristics of each inkjet printer. In color management systems, device characterization is necessary to define device color profiles for use in color management systems. This ensures that original images input into the computer system, images displayed on monitors, and images printed from printers have the same or similar colors [7].

Tools designed for analyzing the printing production process include color strips used for print analysis, such as ECI2002 CMYK or IT8.7/4, which are standard color sets developed by the ECI working group (European Color Initiative) in collaboration with Heidelberger and Gretag Macbeth. These were improved and developed from the ISO 12642 target (IT8.7/3) standard color chart, consisting of 1,485 CMYK standard color patches arranged in a random layout. This printing color chart is popular for determining color characteristics of various devices and can represent color reproduction of all printing systems. It can also be used with digital color printers and various color measurement devices to analyze color gamut, accurately determine color differences$\Delta E*00$, or create color profiles for color management [7].

Asian Pacific Can Co., Ltd. has introduced a new printing material, a white coating, and replaced its rubber blanket. This necessitated the creation of new profiles for both the coating and the blanket. Consequently, the researchers

aimed to develop profiles and compare print quality by conducting proofing tests on paper and film substrates to achieve color matches closely resembling the final printed output. Motivated by these challenges, this research delves into color management for metal packaging prints. Specifically, it explores color management on can prints and compares the characteristics of indirect proofing on film versus direct proofing on paper. By employing a color management system (CMS), the study seeks to address issues such as standardizing blackness according to company specifications and controlling the color gamut of both substrates. The goal is to ensure that the printed output and color gamut closely match or replicate the final printed result, providing alternative proofing material options. Ultimately, the researchers anticipate that both paper and film proofs will exhibit a color difference that is imperceptible to the human eye and closely aligns with the final printed output, with an AE00 value of 2.*

2. Literature Review and Theoretical Framework

2.1 Design a test form sized 1280 x 1095 mm, incorporating a test chart. The original file used for testing was the standard Ugra/Fogra Media Wedge CMYK V3.0 with 72 patches, arranged in Adobe Illustrator 2023 with a resolution set to 300 DPI.

2.2 Create printing plates using Computer to Plate (CTP) technology through the EQUIOS RUNNER - CLIENT program, setting 175 Lpi screen ruling with screen angles of 15° for cyan, 45° for magenta, 0° for yellow, and 75° for black.

2.3 Conduct test printing by loading plates in the order K C M Y R G, setting register marks, controlling print speed at 5,500 sheets per hour, adjusting color settings by controlling density values according to company standards. Begin printing colors on metal sheets and collect the 100th sheet for measurement, verification, and print analysis using measuring instruments to compare print properties.

2.4 Perform test coating by applying varnish on the coating machine, coating printed work once. After varnish coating, pass through a heat oven at 180 ± 3°C for 10-12 minutes. Collect the 100th sheet for measurement, verification, and color profile creation for print analysis using measuring instruments to compare print properties.

2.5 Color Management on Metal Can Packaging 5.1 Basic printer setup: Select "screen dot plus" as the printing method to simulate round screen dots. Choose Roland VS-300i XGINXS printer, set Delta E to 2000, set dot proofing resolution to 175 lpi with screen angles of 15° for cyan, 75° for magenta, 90° for yellow, and 45° for black. Select Color Mode as CMYK OrGr (DXG INKS) + White + Metallic silver (Multi-pass). Choose printing sequence starting with CMYKOG colors, White, and Metallic silver. Set print speed at 350 mm/sec, then select "New linearization" for the printer to output linearization. 5.2 Printer calibration: After printing linearization, measure color values to collect density values using a color coordinate measuring device (15), measuring three positions: A1, A6, and U6. Adjust density values for each color up or down in equal increments. Set ink limit chart to 100, 200, 285, 340, 425, 425, 480 respectively, and for paper, adjust Ink Emit chart to 100, 200, 285, 380, 450, 510 respectively. 5.3 Color correction: Perform color optimization, after which the Oris software will print standard test color charts through the Roland printer. Place the output on the color coordinate measuring device, then the software will process Delta E values. Oris software will optimize color between the printer and Roland device. 5.4 Spot color correction: Select Table and click New, then Browse to the created Queue, select Measurement and choose cmf 01.txt. Select Import spot color and choose PANTONE solid coated.Lab, Select all and choose Import selected. Save to complete the process.

3. Global Trade Theory

3.1 Characteristics of Test Prints

Figure 1: Shows the test print on metal sheet

Figure 1 presents the components analyzed in this study:

Number 1, Standard color test chart ECI 12002CMYK i1_io PM 5.0.5

Number 2, Solid patches: These patches were printed with a solid ink coverage of each individual color (yellow, magenta, cyan, black) to measure ink density.

Number 3, Screen patches: These patches were used to evaluate screen dot gain.

Number 4, Gray balance patches: These patches consist of varying percentages of three process inks combined to produce gray tones, used to assess the gray balance of the inks.

Number 5, Visual assessment: The overall color appearance and sharpness of the printed image were visually evaluated.

3.2 Density Measurement Results
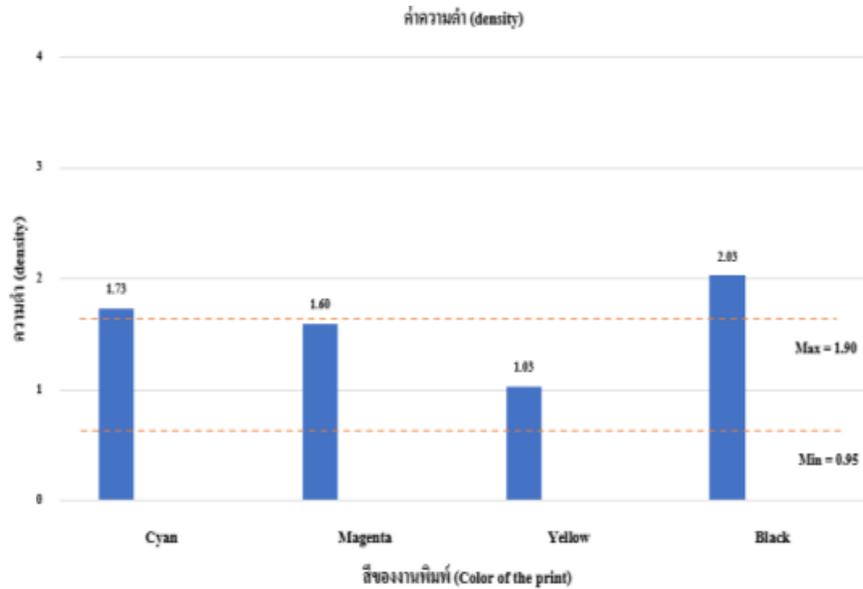
Figure 2: Shows the density graph of 4-color printing

Figure 2 presents the density measurements of the four process colors on a metal substrate with varnish. The results indicate that Cyan exhibited the highest density at 1.73, followed by Magenta at 1.60, Yellow at 1.03, and Black at 2.03. These values slightly exceeded the factory standard, potentially due to excessive ink deposition and the influence of varnish.

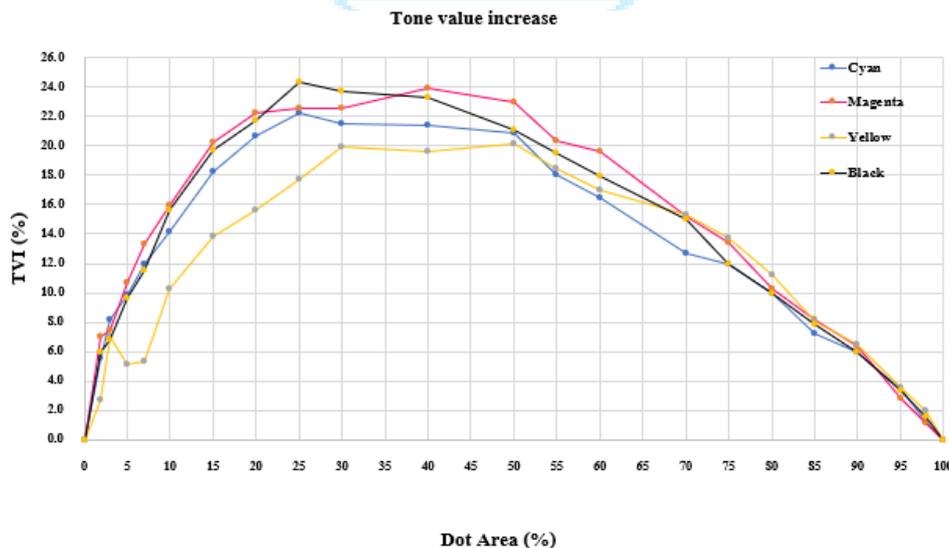## 3.3 Tone Value Increase (TVI) in Printing

Figure 3: Shows the dot gain graph for 4 colors on the varnished test print

Figure 3 illustrates the screen dot gain for the four process colors on the test print after varnishing. The data reveals that Cyan at 25% screen had a dot gain of 22.3%, Magenta at 40% had a dot gain of 23.9%, Yellow at 50% had a dot gain of 21.1%, and Black at 25% had a dot gain of 24.4%. The significant increase in dot gain is attributed to the yellowing properties of the varnish.

3.4 TC1617 Standard Color Test Chart

3.4.1 Color Simulation on Paper
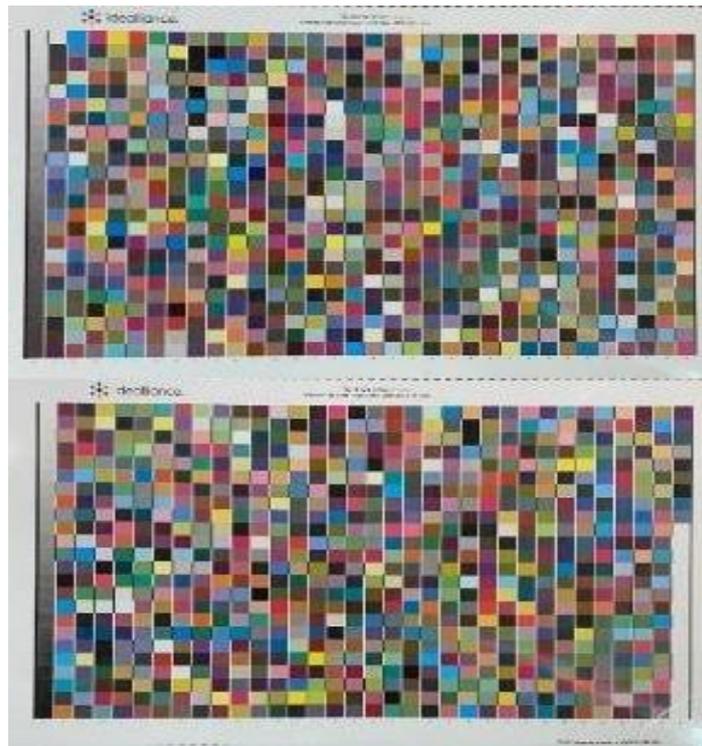

Figure 4: TC1617 Test Chart on paper

Figure 5: Inkjet printer linearization before color compression

Figure 6: Inkjet printer linearization after color compression

The results figure 4-6 show that post-compression linearization produced more intense colors, as the color values were compressed to match the test print values, resulting in greater color intensity compared to pre-compression.

3.4.2 Color Simulation on Film

Figure 7: TC1617 Test Chart on film

Figure 8 Inkjet printer linearization before color compression

Figure 9: Inkjet printer linearization after color compression

The results figure 7-9 show that post-compression linearization produced more intense and glossier colors, as color values were compressed to match test print values.

3.5 Comparison of TVI Values on Film and Paper

3.5.1 *Dot Gain Values on Paper*
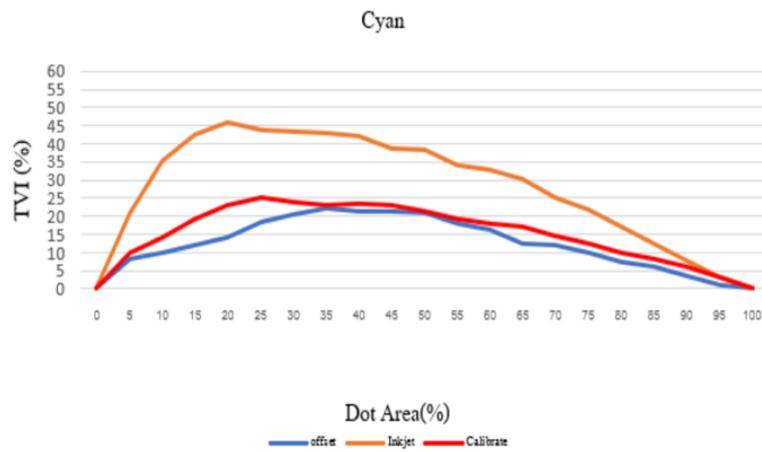
Figure 10: Dot Gain Values on Paper for Cyan
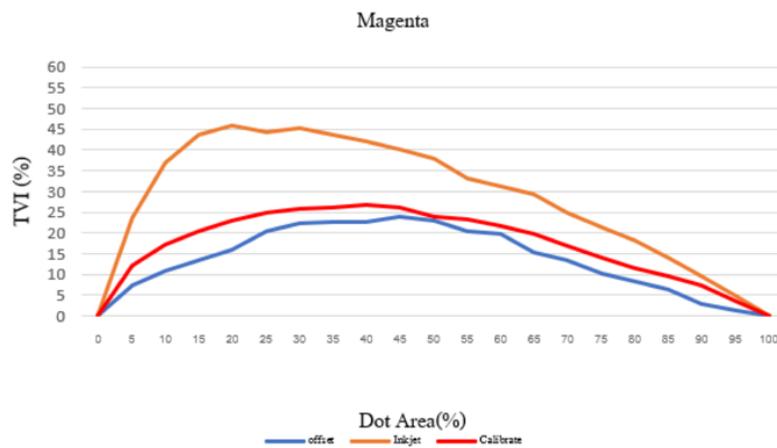
Figure 11: Dot Gain Values on Paper for Magenta
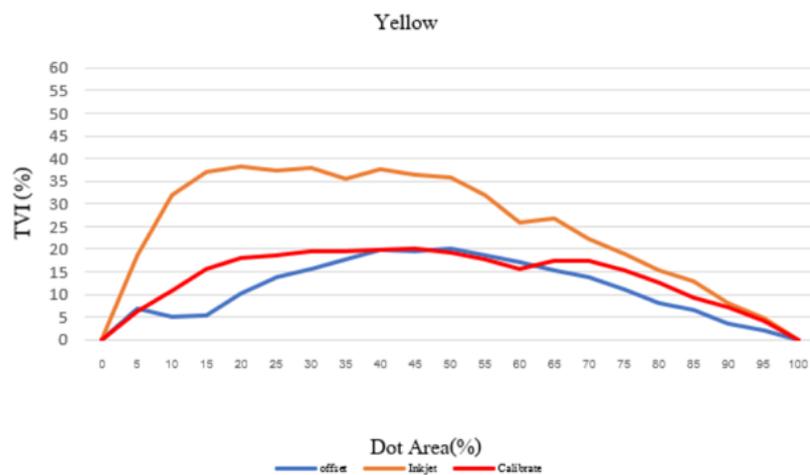
Figure 12: Dot Gain Values on Paper for Yellow
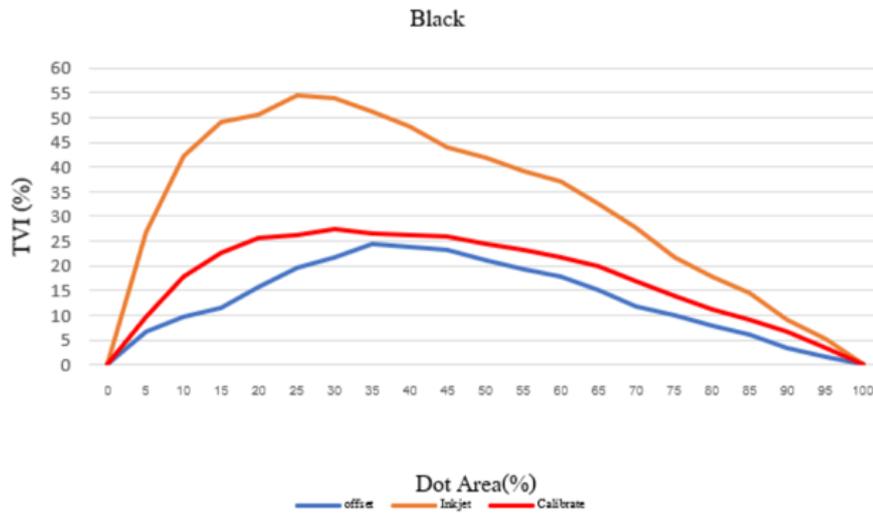
Black

Figure 13: Dot Gain Values on Paper for Black

Figures 10 through 13 present graphs comparing the dot gain linearization values among offset printing, inkjet printing without color compression, and inkjet printing with color compression on paper. The analysis reveals that inkjet printing without color compression exhibits higher dot gain values for cyan, magenta, yellow, and black. After color compression, the linearization of the compressed inkjet printing demonstrates dot gain values more closely aligned with offset printing linearization. This indicates that following color compression, the dot gain values for cyan, magenta, yellow, and black were reduced significantly. Notably, in the shadow and highlight regions, the linearization curves of the compressed output closely approximate those of offset printing. In the midtone regions, cyan, magenta, yellow, and black exhibit slightly higher dot gain values compared to offset printing linearization, though the difference is minimal.
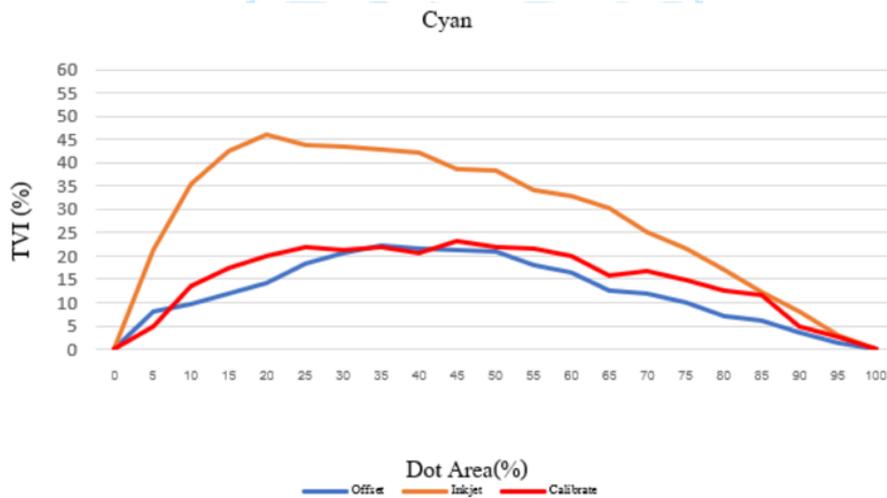
3.5.2 Dot Gain Values on Film

Cyan

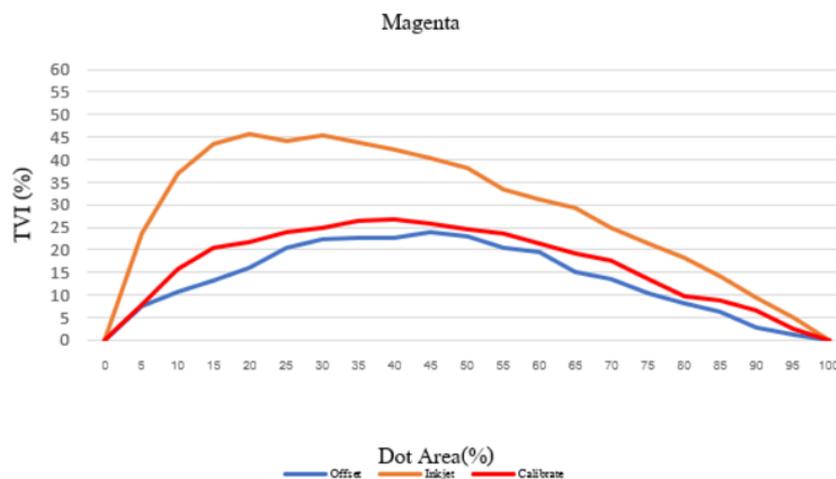**Figure 14**: Dot Gain Values on Film for Cyan

Magenta

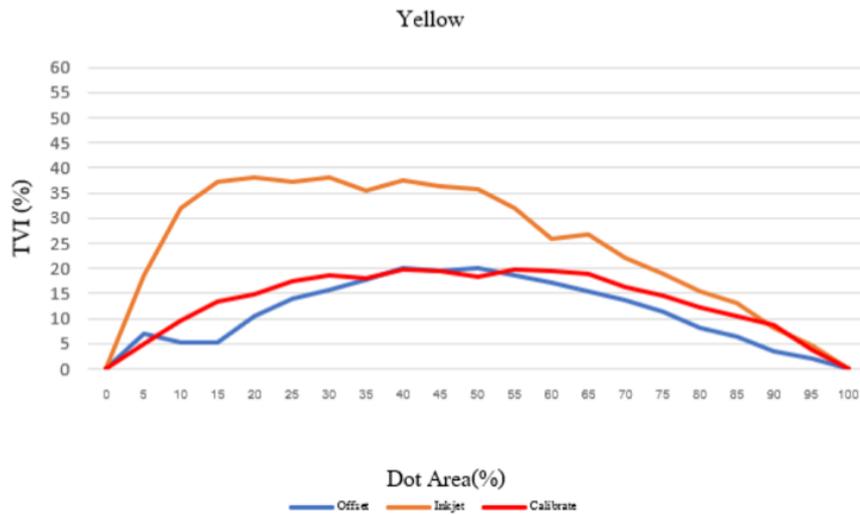**Figure 15:** Dot Gain Values on Film for Magenta

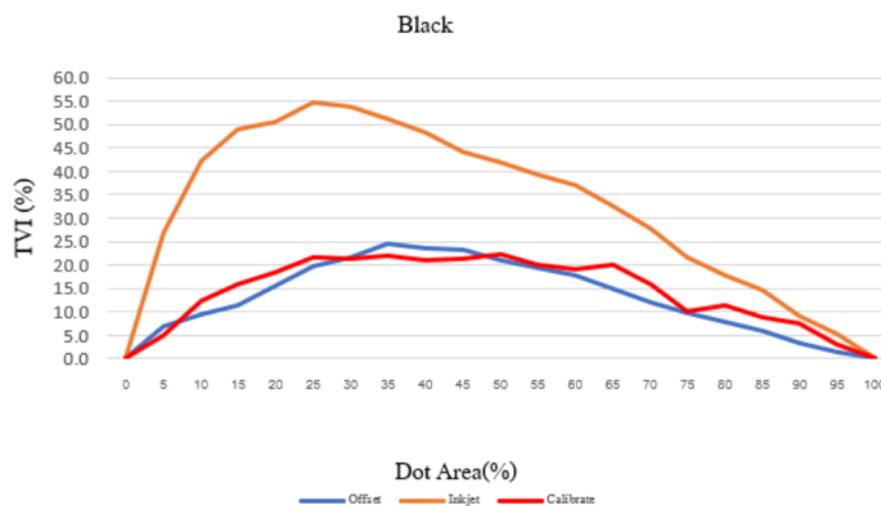**Figure 16:** Dot Gain Values on Film for Yellow

Figure 17: Dot Gain Values on Film for Black

Figures 14 through 17 present comparative graphs of dot gain linearization values among offset printing, non-compressed inkjet printing, and compressed inkjet printing on film. Analysis reveals that non-compressed inkjet printing exhibits higher dot gain values for cyan, magenta, yellow, and black. Post-compression, the linearization curves of compressed inkjet printing approximate those of offset printing. This indicates that following color compression, the dot gain values for magenta and black decreased significantly. The compressed linearization values closely align with offset printing linearization. For cyan and yellow, slight variations in dot gain persist in shadow and highlight regions compared to offset printing linearization, though these differences are minimal.

3.6 Analysis of Color Print Images - Comparative Study

Image Comparison 1

(a)   (b)
Figure 18: Varnished Print Comparison- Production Print (a) and Paper (b)

Analysis of Figure 18 indicates that varnished prints on paper exhibit increased color density in the thread spool and fish areas, resulting in heightened saturation that deviates from true representation. However, these varnished paper prints maintain acceptable parameters within company standards, with visual analysis indicating satisfactory similarity.
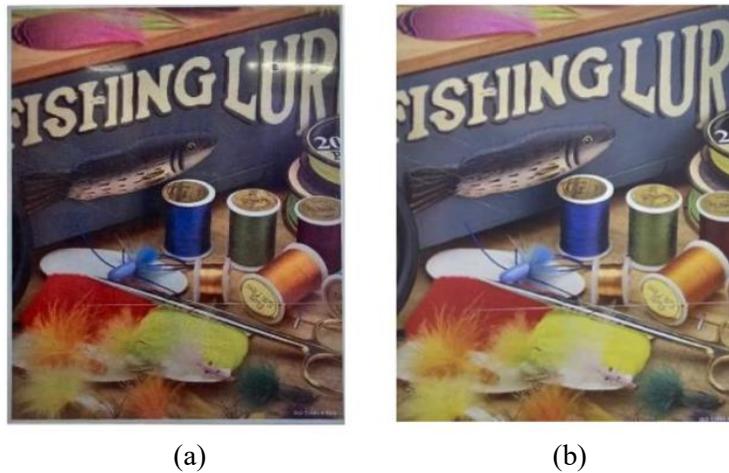
Image Comparison 2

(a)   (b)

Figure 19: Varnished Print Comparison - Production Print (a) and Film (b)

Figure 19 analysis reveals that varnished prints on film demonstrate enhanced saturation and color vibrancy in the thread spool area compared to production prints. The increased color density results from varnish application, which enhances black values and shadows, intensifying the overall color saturation on film. Visual assessment indicates acceptable similarity.

Image Comparison 3

(a)   (b)

Figure 20: Print Comparison between Varnished Production Print (a) and Paper Print (b)

Analysis of Figure 20 reveals that the varnished paper prints demonstrate optimal metallic representation in the spoon area, achieving the highest degree of metallic simulation. However, other elements exhibit higher surface density than the original, particularly in the box and bow areas, which display significantly increased color density. When compared to production prints, the post-varnish paper prints most closely approximate client requirements, falling within acceptable parameters. Visual analysis confirms satisfactory similarity between the samples.

Image Comparison 4

(a)   (b)

Figure 21: Print Comparison between Varnished Production Print (a) and Film Print (b)

Analysis of Figure 21 indicates that varnished film prints exhibit increased color density in the metallic spoon area, resulting in reduced visual authenticity. The box and bow regions demonstrate excessive surface density compared to production prints. This observation confirms that varnished film prints produce higher density values overall. Nevertheless, the results maintain acceptable proximity to client requirements and fall within acceptable tolerance parameters. Visual assessment confirms comparable similarity between the samples.
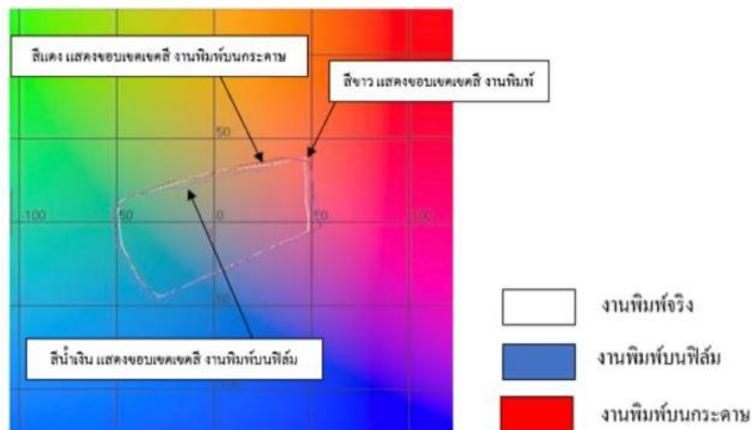
3.7 Color Gamut Analysis

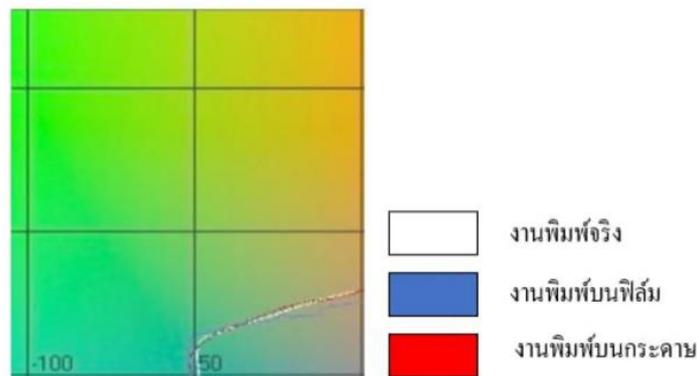**Figure 22:** Comparative Color Gamut Analysis

Figure 23: Color Gamut Comparison - Quarter 1

Analysis of Figure 23 demonstrates that film-based prints exhibit the widest gamut in green regions, while paper-based prints show comparable gamut width in green areas, most closely matching production prints.
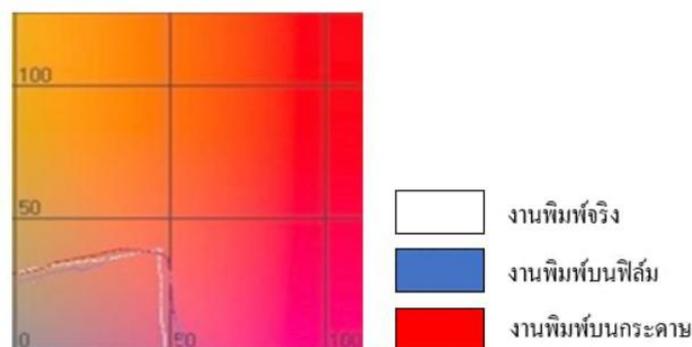

Figure 24: Color Gamut Comparison - Quarter 2

Analysis reveals maximum gamut width for film prints in orange and red regions, with paper prints showing optimal gamut width in orange areas, closely approximating production prints.
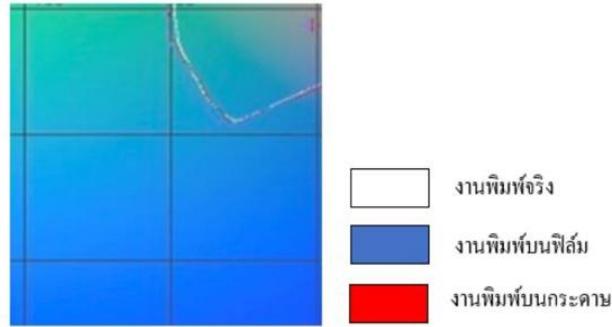
Figure 25: Color Gamut Comparison - Quarter 3

Analysis indicates similar gamut width for both film and paper prints in cyan regions, closely matching production prints.
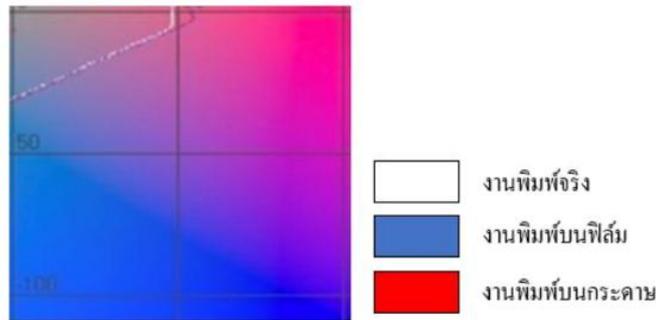

Figure 26: Color Gamut Comparison - Quarter 4

analysis shows both film and paper prints exhibiting slightly wider gamut than production prints in purple regions, attributed to inkjet density characteristics.

3.8 Metal Can Print Comparison

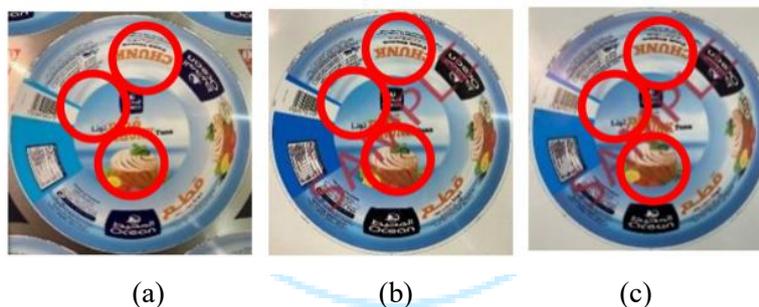(a)   (b)   (c)

Figure 27: Print Comparison - Production Print (a), Film Print (b), Paper Print (c)

Analysis of Figure 27 demonstrates that paper-based prints achieve optimal similarity to production prints, particularly in orange text areas, background elements, inner borders, and fish texture representation. While film prints show increased density affecting visual similarity, paper prints maintain closest approximation to client requirements, confirmed through visual analysis.

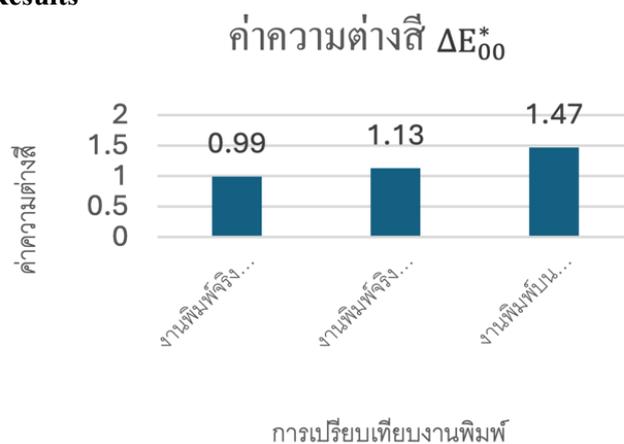## 3.9 Color Difference Analysis Results

Figure 28: Color Difference Graph Comparing Production Print, Paper Print, and Film Print

Analysis of Figure 28 presents CIE Lab* color coordinate measurements comparing production prints, paper prints, and film prints. The comparative analysis was conducted between production prints versus paper prints, production prints versus film prints, and paper prints versus film prints. Results indicate minimal color difference between production prints and paper prints, demonstrating that paper-based printing achieves close approximation to production prints, whereas film prints exhibit greater color variation.

4. Conclusions and Discussion

This research study on color management for metal can packaging, conducted at Asian Pacific Can Company Limited, compared indirect proofing on film and direct proofing on paper against production prints. Testing was performed according to ISO 12647-1 and ISO 12647-2 standards. The findings reveal that paper prints achieve closer color matching to production prints compared to film prints. This variance is attributed to the indirect printing process of film, which involves lamination, resulting in increased black density values and elevated TVI curves, leading to higher color saturation and glossiness compared to both paper prints and production prints.

However, the color difference ($\Delta E_{*00} < 2$) indicates that both film and paper prints remain within acceptable standards. These findings align with research conducted by Pitak Boonprasom and Nattapong Limjitti on color management systems for sheet-fed offset printing. Their research demonstrated significant color variations in non-color-managed inkjet printing compared to color-managed printing, with color-managed output maintaining acceptable differential parameters. This confirms that color management systems effectively control device output consistency.

Our research demonstrates that paper-based printing can achieve production print equivalency with comparable color gamut representation. To optimize cost-efficiency and reduce proofing time, paper proofing is recommended over film proofing to minimize expenses and reduce film waste.

Acknowledgement

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